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## ON THE DISTRIBUTION AND PRIMITIVE NUMBER OF SPIRACLES IN INSECTS.\*

BY A. S. PACKARD, JR.

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WHILE engaged in dissecting certain Sphinx and Bombycid larvæ, my attention was called to an interesting feature in the distribution of the thoracic portion of the main tracheæ and their stigmatal branches. In the larva of Sphinx and of *Platysamia cecropia*, and in fact so far as I am aware in all lepidopterous larvæ, there are nine pairs of spiracles, or stigmata, of which eight are abdominal, there being a pair to each first eight segments of the abdomen; while there is but one pair of thoracic spiracles, which are invariably, so far as I am aware, situated on the prothoracic segment. On laying open the body of a Sphinx larva a large number of branches are seen to arise from the prothoracic and basal, or first pair of abdominal spiracles. Now between these two points it will be remembered that there are no spiracles or any external signs of them. And yet the main trachea between these two spiracles deviates from its course and bends down to send off a small trachea to the place where, did a spiracle exist, we should look for it, *i.e.*, to a point in the suture between the mesothoracic and metathoracic segments, where in hymenopterous larva a spiracle does exist. From the upper side of the main trachea two larger branches are sent towards the interior of the body. These apparently correspond with the numerous branches sent off from the spiracles.

In *Platysamia cecropia* the same disposition of the main trachea may be seen, as it bends out in the same way towards the usual site of the spiracle in other groups of insects, and throws off three branches, one outward towards the tegument, small, and apparently rudimentary, while the two others, directed inwards, are larger than in Sphinx.

This has led me to ascertain how the spiracles are distributed in other groups of insects, and what is their usual number. While in the lepidopterous larvæ there is but one pair of stigmata, which are situated on the prothoracic, or first thoracic, seg-

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ment, in the larvæ of the higher Hymenoptera, *i.e.*, the bees and wasps (I have examined *Bombus*, *Xylocopa*, *Halictus*, *Andrena*, *Vespa* and *Polistes*), there are no spiracles on the prothorax, but a pair on each of the two following thoracic segments. In all these the thoracic spiracles are as well developed as those on the abdomen, and in *Bombus* larvæ the tracheæ proceeding from the spiracles are as well developed, being large and elongate barrel-shaped just after leaving the stigmata, and beyond subdividing into several branches. In two genera of Tenthredinidæ, and probably in the family generally, the spiracles are arranged as in the lepidopterous larvæ, there being but one pair, the prothoracic. In the Uroceridæ, however, *Tremex* in its larval state has two pairs, one prothoracic and one metathoracic, the anterior pair twice as large as the posterior pair. So it would seem that while no known hymenopterous larva has more than two pairs of spiracles on the thorax, yet three pairs may be found on different rings in different groups, though not actually existing in one individual. The ideal number of pairs is three, or for the entire body eleven. In the Diptera the Cecidomyiæ have nine pairs of stigmata, of which one is thoracic (on the prothorax), while the eight other pairs are abdominal. In the Muscidæ, there are two pairs only, one prothoracic, the other anal, or situated on the ninth segment of the abdomen. So that in this group we have ten segments which bear spiracles, though no single species is known to have more than nine pairs of spiracles.

In the Coleoptera there are usually nine pairs of spiracles, one thoracic, and eight abdominal. The thoracic spiracles are either on the pro- or meso-thoracic segment.\* In the adult *Melolontha* and other beetles Strauss shows that a spiracle exists between the meso- and meta-thorax, which is not present in the larva. If this be so, then the ideal number of pairs in Coleoptera is ten.

In the Hemiptera and Orthoptera† there are two pairs of thoracic spiracles present on the two anterior segments; and

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\*It is often difficult to say on which segment of the coleopterous larvæ the thoracic spiracles are placed, they are so near the suture separating the pro- and meso-thoracic segment, and authors differ considerably about them. In the larvæ of *Carpophilus*, *Cetonia* (by some they are stated to be on the meso-thoracic ring), *Anobium*, *Tomicus* and *Xanthochroæ* the spiracles are said to be placed on the prothoracic ring (Candez). In *Magdalinus* they are situated on the suture between the segments, and in the Longicorns they are in some genera placed on the posterior edge of the prothoracic, and in others on the anterior edge of the meso-thoracic ring.

† Gryllidæ and Acrydii (Dufour).

in the Neuroptera\* there are the same number, but none on the prothorax.

In the larva of *Corydalus cornutus* there is a pair of spiracles on the prothorax, but they are no larger than those on the basal segment of the abdomen. It is difficult to say whether they are situated on the prothoracic or mesothoracic segment, but I am inclined to regard them as placed on the extreme hind edge of the prothoracic ring.

A curious fact may be here mentioned, as I have not seen it noticed before, regarding the distribution of the tracheæ in the larva of *Corydalus*. The main tracheæ suddenly enlarge from the second abdominal spiracle to the base of the head, when it subdivides and distributes branches to the head. From the spiracle on the basal abdominal segment a trachea, as large as the anterior swollen portion of the main trachea, takes its origin and passes directly under the main trachea. Now both tracheæ send a branch opposite to where the mesothoracic stigma should be, if present, *i.e.*, on the hind edge of the ring. Both branches of the tracheæ, the main one and its fellow, anastomose perfectly over the branch sent off to the prothoracic spiracle.

This doubling of the tracheæ, which are so very large, forms evidently an hydrostatic, as well as respiratory, organ and serves to lighten the anterior and heavier portion of the body, as in the dilated air sacs of the terrestrial insects. This fact seems to sustain the view of Gegenbaur,† that the tracheæ were at first closed, forming air-bladders, and afterwards performed the function of respiration.

It would appear from these facts that while no more than ten pairs of spiracles are to be found on the bodies of any one species of the groups of insects above mentioned, yet that eleven segments of the body, in different species taken collectively, bear them. Now if we turn to the Thysanurous genus *Campodea*, we shall find on the authority of Meinert that it bears spiracles on each thoracic segment. From this fact we are inclined to regard eleven as the normal primitive number of pairs of spiracles. Probably the larvæ of the different groups of winged insects had originally a pair on each thoracic segment. Certainly at least on evolutional grounds from the indications in existing caterpillars

\* There are two pairs of spiracles in the meso-thoracic and meta-thoracic rings respectively in the Libellulidæ and Ephemeridæ (none abdominal, as the larvæ have none), and in the Myrmeleons and Perlidæ.

† C. Gegenbaur, *Gründzüge der Vergleichenden Anatomie*, 2te Auflage, 1870. p. 437

we are perhaps warranted in concluding that the ancestral type of lepidopterous larvæ was provided with two pairs of thoracic spiracles.

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## GEOGRAPHICAL VARIATION IN NORTH AMERICAN BIRDS.\*

BY J. A. ALLEN.

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PROBABLY the birds of no equal area of the earth's surface are better known than those of North America north of Mexico, or of the whole continent southward even to the Isthmus of Panama. No museums in the world, probably, possess so large suites of specimens of single species as there are of North American birds in the Museum of the Smithsonian Institution and in the Museum of Comparative Zoology, nor from so many localities. In many instances single species are represented by hundreds of specimens collected at frequent intervals throughout their known range. Those contained in the Smithsonian Institution have been most carefully elaborated by Prof. Baird and others, whose reports upon them have justly acquired a world-wide reputation for their thoroughness and accuracy. Those in the Museum of Comparative Zoology have also been carefully studied.

Briefly, then, what are the facts and the general results that have followed the investigation of this exceptionally large amount of material? What are the allowable inferences, and what general principles have been apparently established? To answer these questions as briefly as may be is the object of the present remarks, — premising, however, that the formerly current opinions respecting the rank of a certain class of forms heretofore generally regarded as specific have been radically modified. Intergradation has been frequently traced between widely different forms, a gradual coalescence in scores of instances having been positively established, and rendered extremely probable in a large number of others.

In North America geographical variation exhibits two marked phases : — (1) a differentiation with differences of latitude and elevation, and (2) differentiation with differences of longitude ; which, for convenience, may be termed respectively latitudinal

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\*From the Proc. Bost. Soc. Nat. Hist., vol. xv, p. 212.